IDENTIFICATION OF SUITABLE BLUE SWIMMER CRABS SPECIES COMPLEX FOR REARED IN BRACKISH WATER POND

Yushinta Fujaya *, **Dody Darmawan Trijuno, Andi Ivo Asphama, Nur Alam**

Faculty of Marine and Fisheries Science
Hasanuddin University
Campus Tamalanrea UNHAS Makassar 90245, INDONESIA
yushinta.fmuskar @gmail.com

ABSTRACT

Blue swimmer crab is a species complex with various characteristics. This study aims to access the potential of blue swimmer crab to be used as aquaculture animals by selecting the species were most suitable reared in brackish water pond. In this study, twenty wild berried female regardless of species were naturally hatched in the hatchery and their larva reared until crab instar. Then, the crab seeds were reared in brackish water pond for three months. Observation was conducted at harvest on number and size in carapace width for each identified species. Species identification based on the color, pattern of white spots on the carapace, and the number of spines on cheliped merus. Suitability as aquaculture animals is characterized by a high number and large size of crab. The results showed that there were at least three species of blue swimmer crab survival in brackish water pond after three months rearing period. The species were *Portunus pelagicus, P. armatus,* and *P. reticulatus.* There were variations in number and sizes of harvest among these species. Number of harvested crab were 66% of *P. Pelagicus,* medium size group (average carapace width of 97 mm), 31% of *P. armatus,* largest size group (average carapace width 108 mm) and 3% of *P. reticulatus,* smallest size group (average carapace width of 90 mm). It is concluded that *P. pelagicus* and *P. armatus* were the two species are suitable for aquaculture in brackish water pond. Domestication of the two species is important for the development of aquaculture in the future.

Key words: blue swimmer crab, species complex, aquaculture, brackish water pond.

INTRODUCTION

Blue swimmer crab is the world fishery resources with high market demand. The crab is exported to foreign countries with growing demand from year to year. FAO (2014) reported that the total catch of this species in 1999 was 133 938 tons, in 2010 total catches increased by nearly 200,000 tons, and in 2012 fell to around 180,000 tons. As a result of this massive exploitation, several countries have reported a decrease in population (Johnston et al., 2011; Mehanna et al., 2013; Harris et al., 2014; Kunsook et al., 2014).

Blue crab supply largely from wild crab catches at sea and only small portion from cultivation. Although, Williams and Primavera (2001), has recommended *Portunus pelagicus* as cultivated candidate species because this species has a market, variety of products can be developed from this species, the broodstock is available, and has a wide distribution, but until now it has not been widely cultivated. FAO (2014) noted that the global aquaculture production is only about 30 tons in 2010, this production rate decreased to below 20 tons in 2012

Various obstacles were encountered in the development of crab cultivation include hatchery and rearing technologies that are not yet fully mastered. Crab production in hatchery is still unstable, high level of cannibalism, slow growth and survival rate are during grow-out phase in pond. Maheswarudu et al. (2008) reported that survival rate of larva from different broodstock eventhough cultured in the same rearing method was varied from 5.3% to 16.6% with stocking density of 50 ind / L and 0.8% - 2.6% with a stocking density of 100 ind / L. Fujaya et al. (2014) found that the cause of crab larva mortality were 57.47% was not identified since the dead larvae appeared normal, 15.61% caused by failed molting, 17.65% caused by fungal attack, and 9:28% due to abnormal morphology. Variation of larval survival rate is strongly assumed caused by different rearing methods and broodstock quality in which broodstock influence the larva performance in facing the spesific hatchery environmental condition.

Up to now, blue crab management and development refers only to a single species, namely *P. pelagicus.* In fact, according to a report of Lai et al. (2010) that the blue crab is a species complex consisting of four species, namely: *P. pelagicus, P. reticulatus, P. segnis, and P. armatus.* Each species would have different characteristics. The genetic differences of these species is more likely to affect a wide range of characteristics needed in the cultivation of the crab such as high growth rate, resistant to rearing environmental stresses, resistant to diseases, lower feed conversion ratio, and other characteristics associated with the production.

In this study, pre-selection of suitable species for rearing in brackish water ponds was conducted. Suitability of species is determined from high adaptability to the pond environmental condition and growth rate to reach market size. In this paper, various blue crab characters in relation to aquaculture are discussed.

MATERIAL AND METHODS

Broodstock collection

Berried broodstock that has been holding a black egg was collected randomly regardless species names and morphological features, from blue crab fisherman. The broodstocks were catched around in the sea around southern part of Barru Regency, South Sulawesi, Indonesia The broodstock were transported in the aerated plastic container to the hatchery and placed it into the 2 tonnes concrete tank.

Hatching and larval rearing

Eggs hatching was done in small scale hatchery located in the village of Bojo, Barru Regency South Sulawesi, Indonesia. Twenty berried female crab that has been carrying eggs were divided into 2 groups: 10 female for hatching in the period 1 and 10 female for hatching in the period 2. Each group of ten females were stocked into one concrete tank volume of 2 tonnes for hatching in each period. After hatching, the spent females were taken out from the tank and zoea was maintained in the tank for two days. After day 2, the zoea was transferred into another concrete tank at stocking density of 30 zoea / L to be reared until crab phase. During rearing period, the zoea was fed on rotifers, Artemia nauplii, and artificial feed (Table 1). During the rearing period, water quality was mainatained in the range of 30-32°C for temperature, 31-33 ppt for salinity, and 4-5 ppm for dissolved oxygen.

Table 1. Feeding Scheme Used for Rearing *Portunus pelagicus* species complex.

Food Types	Crab Larvae Stages					
	Z1	Z2	Z3	Z4	M	C
Rotifer (Brachionus spp.) (ind/mL)	**20**	**20**	**20**			
Artemia nauplii (ind/mL)			**2**	**2**	**2**	
Artificial Feed (ppm/day)		**2**	**2**	**4**	**4**	**4**
Crushed Stewed Fish (ppm/day)						**4**

Grow-out blue crab in the pond

Crab seed resulting from the hatchery above in the phase of instar 5 crab was reared in the 3000 $m^{2.}$ brackish water earthen pond at density of 0.5 ind/m^2. During this grow-out period, crabs were fed on dried chopped fish at a rate of 2% of the estimated total crab weight. Water exchange in the pond was done following the daily tidal water. Seaweed *Gracillaria* sp was also stocked in the pond for crab shelter. The blue swimmer crab was reared for 90 days. Harvest was dones manually and the whole harvested crab was collected, counted graded and grouped based on the size and number following morphological differences.

Measurement of variables

The parameters measured in this study were the percentage of the number and size of each species of harvested crab. Measurement was performed on males crab only because of color variations and spots were clearly visible on the male crab. The identification of species is based solely on morphological followed Lai et al. (2010) instructions (Table 2). The measurement of carapace width using a caliper with a precision of 1 mm.

Table 2. List of morphological differences among the species in the *Portunus pelagicus* complex (after Lai et al., 2010)

Species/ Characters	***Portunus pelagicus***	***Portunus segnis***	***Portunus reticulatus***	***Portunus armatus***
The carapace color	Males possess a dark blue-green with purple-blue carapace chelipeds. Both the males and females possess white spots on the carapace, merging into broad Often almost branded reticulations, in particular on the posterior and branchial region	Males with dark blue-green carapace with discrete white spots on the carapace, sometimes merging into thin reticulated bands. Females similar to the males; spotting on the posterior third or carapace	Males have greenish-blue carapace, covered with large pale green spots, rarely merging into short bands. Females are tending to brownish green carapace; reticulated pattern as for males, the tips of chelipeds rusty red	Color variable; lazy typically with dark blue-green carapace, but the South Australian specimens more blue than green. Spots on the carapace sparser than other species, discrete, fusing into thin irregular short bands anteriorly; numerous small spots particularly subject postero-laterally. Female brownish with deep brownish-red cheliped tips; -similar pattern of spots and reticulation to lazy
Cheliped merus	Relatively long, slender	Relatively long, slender	Relatively shorter and stouter	The shortest and stoutest
Spines on the anterior margin of cheliped merus	3	3	3	4

RESULTS

Morphological variations such as carapace color, spot pattern, cheliped shape and number of spine on the cheliped merus, were observaed on the harvested crab (Table 3). A very large variation in morphology expecially on spot pattern found in this study.

Referring to the morphological characteristics of each *"species complex" P. Pelagicus* proposed by Lai et al. (2010), the crab is harvested from the pond can be divided into 3 groups: group 1 was similar to *P. reticulatus,* group 2 was similar to *P. armatus,* and group 3 was similar to *P. pelagicus.* There were difficulties in determining the species of group 2 because of the characteristics described by Lai et al. (2010) did not entirely match to the characters of *P. armatus.* In group 2, white spots on the carapace were rare, but in this case the white spots

were large and small, and number of spines on the right outer side of cheliped merus was 3 or 4. Shape of cheliped merus which was relatively long and slender was not stated in the Lai et al. (2010) report as a characteristic of *P. armatus.* However, based on the photo presented in the Lai et al. (2010) report, crabs of group 2 was more similar to *P. armatus,* than *P. segnis.* It is needed more careful observation in the future. However, in this study, crab in the group 2 is more likely to be grouped as crab species of *P. armatus* based on the number of spines on the outer side of cheliped merus.

Table 3. Morphological characters of crabs harvested from brackish water pond after 3 months rearing periods.

Morphological characters	Group 1 *(P. reticulatus)*	Group 2 *(P. armatus)*	Group 3 *(P. pelagicus)*
Carapace color	Turquoise	varies from dark blue to blue-purple	dark blue-green
Spot Pattern	small pale green spots on the whole carapas	rare white spots; varies spots size; some large and some small white spots far apart	white spots on the whole carapace
Shape cheliped merus	relatively short and podgy	relatively long and slender	relatively long and slender
Number of spines on the outer side cheliped merus	3	3-4	3

Percentage of harvested crab and size varied among the three groups of identified species (Figure 1 and 2). Percentage of harvested crab for each species, the highest was 66% for *P. pelagicus*, 31% for *P. armatus* and the least was 3% for *P. reticulatus.* In terms of

average and range of size, the biggest was *P. armatus* (108 mm, 80-139 mm), followed by *P. pelagicus* (97 mm, 60-129 mm) and the smallest was *P. reticulatus* (90 mm, 70-109 mm).

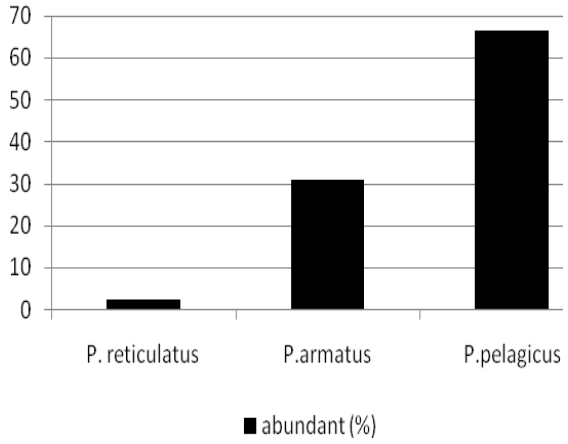

Figure 1. Percentage of the three harvested crab species after 3 months rearing in the brackish water pond

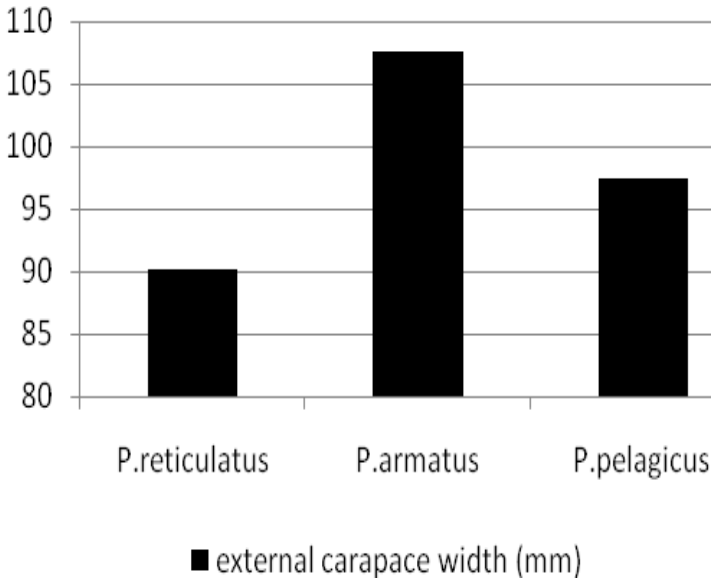

Figure 2. Size of the three harvested crab species after 3 months rearing in the brackish water pond

DISCUSSION

The results of this study indicate that the selection of species for cultivation is very important. Each species has its own characteristics. Thouard et al. (1989) recommended that adaptability to culture environmental, rearing techniques, and socio-economic as major factors in the selection of species for cultivation. By choosing a species that grow faster and resistant to rearing environmental stress will suppress directly on the cost of production. According to Fang and Yan (2012), there are some aspects economically important for cultured animal, among others: reproduction, sex, growth, resistance to diseases, tolerance to changes in temperature and hypoxia.

Based on the percentage of harvested crabs in this study, *P. pelagicus* and *P. armatus* have high potential to be chosen as candidate species for aquaculture. These two species successfully survive and in the rearing condition in which sometimes the environment condition fluctuates. The two species grew faster to the market size in the relatively short time. Within 120 days (20 days was a larval period in the hatchery and 100 days was the grow-out period in the pond), *P. pelagicus* reached 97 mm and *P. armatus* attained 108 mm in average sizes. In addition, after 3 months rearing period in the pond some crabs were found successfully developed their gonad until a period of carrying fertilized eggs (berried female).

Although complexity of *P. pelagicus* species is still under debatable among researchers, but in this study it is necessary to determine the species for groups of crab that morphologically different and also implies differences in adaptability and growth during the rearing period. Lai et al. (2010) suggested that *P. pelagicus* is species complex which actually consists of four species, namely *P. pelagicus, P. segnis, P. reticulatus,* and *P. armatus.* Geographycal distribution of these four species were *P. pelagicus* in Indonesia, Malaysia, Philippines, Taiwan, Japan, and China. *Portunus segnis* found in Israel, Arab, Pakistan, Madagascar, and Mosambique; *P. reticulatus* in India, Sri Lanka, and Thailand. *Portunus armatus* was found in

Australia and New Caledonia. Other researchers have suggested that *P. pelagicus* in the Philippines allegedly was a cryptic species. It is more likely the cryptic species consisting of two species based on mt DNA analysis which was confirmed by DNA sequence registered in GenBank (Sienes et al., 2014). Some literature mentions that cryptic species is a synonym of "sibling species". Other also categorized as pseudo-sibling species or camouflaged or secretive species (Bickford et al., 2008). Therefore, misidentification of this species may provide serious negative consequences in fisheries management of the crab (Bickford et al., 2006).

Although, according to Lai et al. (2010), the species blue swimmer crab distributed in Indonesia, only *P. pelagicus,* but in this study a very large variation in morphology and DNA among the observed crabs from Indonesian waters, therefore, the crabs were clustered into three species groups, namely *P. reticulatus, P. armatus, and P. pelagicus.* This grouping was done because differences among the species have implications on the production aspect. Asphama (2014) reported that there were high variation in morphometric characters and DNA among the blue crab species found in the waters of Makassar Straits including the waters around Barru Regency. There are some possible explaination for this fact, hibridization among the crab species or migration of *P. reticulatus* from the northern parts of Indonesia and migration of *P. armatus* from the southern part of Indonesia or other possible causes. This is still need to be investigated.

Maheswarudu et al. (2008) from India reported that *P. pelagicus* is potential species for aquaculture. Juvenil of *P. pelagicus* cultured in brackish water pond with a stocking density of 2.6 first crab instar/m2 was successfully harvested at amount of 784 kg/ha on day 135 with a 32% survival rate and food conversion ratio was 1.8. The market size of the crab is 116 mm in carapace width or 112g in weight. Gonad maturity achieved after 5 months (20 days larval period and 134 days grow-out period). After 135 days, the live crabs can be transferred into the recirculating tank for soft-shelled blue crab production. Zeng (2008) also suggested that the *P.*

Pelagicus has a high growth rate, may spawn in a rearing environment and its breeding and larval rearing is relatively easy. This crab has a high market value especially for "soft-shelled crab" and "canned crab meat".

Harris et al. (2014) has revised the name of the blue swimmer crab found in Shark Bay, Western Australia that previously named *P. Pelagicus* into *P. armatus* based on description of Lai et al. (2010). Kangas (2000) reported that the blue swimmer crab in Shark Bay, Western Australia has an incubation period up to the release of eggs in 10-18 days, and larval period takes up to 6 weeks. This crab reaches legal market size in 12-14 weeks and will naturally die at age of 2 0 months (Potter et al., 2001) or the living period of the blue crab until 3-4 years.

The larval period of the blue swimmer crab from Shark Bay is .relative longer compares to the larval period found in this study. In this study larval period from zoea to instar crab was attained within 15-17 days, is similar found by Josileen and Menon (2004) from India. The egg incubation period of the crab from India is also shorter that is 6-7 days (Soundarapandian and Tamizhazhagan, 2009). These differences are more likely due to differences in species, or perhaps also by differences in water temperature. In Australia, blue swimmer crab spawns when the water temperature starts to warm in the spring before entering summer. While in India, water temperature in culture media was 28 – 31^{o}C is also similar to the temperature in hatchery in this study.

The size of the crabs caught in Shark Bay was dominated by large size, 80 - 90% sized more than 150 mm carapace width (Harris et al., 2014). This crab size is relevant to the statement of Lai et al. (2010) that *P. armatus* is the largest blue crab among the four species complex of *P. pelagicus.* The biggest specimen of *P. armatus* has recorded was 200 mm carapace width. This size character is very important economically for aquaculture.

Development of blue crab aquaculture presents several challenges, including culture environment, nutrition, and behavior. Various studies indicate that although the blue crab has a

high tolerance to ammonia, but they are more sensitive to nitrite. In order for optimize the growth of the crab, nitrite concentration in the water needs to be controlled, it is not exceed 0.1 mg/L. In addition, feed nutrition is also important to be attentioned. Generally, feed applied in the rearing practice of blue crab is shrimp feed or chopped trash fish. There is no special diet for blue crab whish is suitable in term of nutrition and form. Other big problem encountered in the blue crab aquaculture is cannibalism. Cannibalism become a limiting factor in the blue crab aquaculture since high level of cannibalism appears from megalopa to juvenile and adult period Cannibalism generally occurs shortly after molting, because at that time, a protective hard shell is released of the body covered only by a new soft shell and it is easy to be attacked by other crabs (Zeng, 2008).

CONCLUSION

Based on these study,it is concluded that *P. pelagicus* and *P.armatus* are the two species suitable for aquaculture in brackish water pond. Domestication of the two species is important for the development of aquaculture in the future. Some important aspects need to be noticed in the developing blue swimmer crab aquaculture are culture environment, nutrition and feed and typical behavior of blue crabs.

ACKNOWLEDGEMENT

Researchers thank to Ministry Education and Culture Republic of Indonesia for funding this research through the Program of National Priority and Strategic Research.

REFERENCES

Asphama AI. 2014. Genetic Analysis of *Portunus pelagicus* Variety (Linnaeus, 1978) Species Complex from Barru Waters Based on Morphology and DNA Characteristic. Post Graduate Program of Hasanuddin University, Indonesia. 118 pp.

Bickford D., DJ Lohman, NS Sodhi, PKL Ng, R Runny, K Winker, KK Ingram, I Das. 2008. Cryptic species as a window on diversity and conservation. Trends in Ecology and Evolution, 22 (3): 148-155.

FAO. 2014. Species fact sheets *Portunus pelagicus* (Linnaeus, 1758). Fisheries and Aquaculture Department.

Fang GJ., ZZ Yan. 2012. Molecular basis and genetic improvement of economically important traits in aquaculture animals. Hydrobiology, 57 (15): 1751-1760.

Fujaya Y., DD Trijuno, A Nikhlani, I Cahyono, Hasnidar. 2014. The use of mulberry *(Morus alba)* extract in the mass production of blue swimming crab *(Portunus pelagicus* L.) larvae to Overcome the mortality rate due to molting syndrome. Aquatic Science and Technology, 2 (1): 1-14.

Harris D., Johnston D, E Sporer, M Kangas, Felipe N, N Caputi. 2014. Status of the Blue Swimmer Crab Fishery in Shark Bay, Western Australia. Fisheries Research Report No. 233. 79 pp.

Johnston D., D Harris, N Cauti, A Thomson. 2011. Decline of a blue swimmer crab *(Portunus pelagicus)* fishery in Western Australia-History, contributing factors and future management strategy. Fisheries Research, 109: 119-130.

Josileen J., NG Menon. 2004. The larval stages of the Blue Swimer Crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, brachyura). Crustaceana, 78(1): 1-18.

Kangas MI. 2000. Synopsis of the biology and exploitation of the blue swimmer crab, Portunus pelagicus Linnaeus, in Western Australia. Fisheries Research Report No. 121. 22 pp.

Kunsook C., Gajaseni N, N Paphavasit. 2014. A Stock assessement of the blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) for sustainable management in Kung Krabaen Bay, Gulf of Thailand. Tropical Life Sciences Research, 25 (1): 41-59.

Lai CYL., PKL Ng, PJF Davie. 2010. A revision of the *Portunus pelagicus* (Linnaeus, 1758) species complex (crustacea: brachyura: Portunidae), with the recognition of four species. The Raffles Bulletin of Zoology, **58** (2): 199-237.

Maheswarudu G., J Jose, KRM Nair, MR Arputharaj, A Ramakrishna, A Vairamani, N Ramamoorthy. 2008. Evaluation of the seed production and grow-out culture of blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) in India. Indian Journal of Marine Sciences. 37 (3): 313-321.

Mehanna SF., S Khvorov, M Al-Sinawy, YS Al-Nadabi, MN Al-Mosharafi. 2013. Stock assessment of the blue swimmer crab *Portunus pelagicus* (Linnaeus, 1766) from Oman Coastal Waters. International Journal of Fisheries and Aquatic Sciences, 2 (1): 1-8.

Sienes PMQ, DA Willette, LR Romena. 2014. Genetic diversity and the discovery of a putative cryptic species within a valued fishery crab, *Portunus pelagicus* (Linnaeus 1758), in the Philippines. Philippine Science Letters, 7 (2): 317-323.

Soundarapandian P., T Tamizhazhagan, 2009. Embryonic development of commercially important swimming crab *Portunus pelagicus* (Linnaeus). Current Research Journal of Biological Sciences 1 (3): 106-108.

Thouard E., P Soletchnik, JP Marion. 1989. Selection of finfish species for aquaculture development in Martinique. Advances in Tropical Aquaculture, 499-510.

Williams MJ., JH Primavera. 2001. Choosing portunid tropical species for culture, domestication and stock enhancement in the Indo-Pacific. Asian Fisheries Science, 14: 121-142.

Zeng C. 2008. Blue Swimmer Crabs; Emerging Species in Asia. Global Aquaculture Advocate, 34-36.